Issued by the Colonial Office.

EAST AFRICAN AGRICULTURAL RESEARCH STATION, AMANI

ANNUAL REPORT 1939

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EAST AFRICAN AGRICULTURAL RESEARCH STATION, AMANI

STAFF LIST.

Director.—A. G. G. Hill, B.A., B.Agr., B.Sc., A.R.C.Sc.I.

Plant Pathologist.—H. H. Storey, M.A., Ph.D.

Entomologist.—T. W. Kirkpatrick, M.A., Dipl. Agric. (Cantab.), F.R.E.S.

Soil Chemist.—G. Milne, M.Sc., F.I.C.

Biochemist.—R. R. Le G. Worsley, A.R.C.S., B.Sc., Ph.D., D.I.C.

Plant Physiologist.—F. J. Nutman, D.Sc., D.I.C.

Plant Physiologist (2).—J. Glover, M.Sc. (Botany).

Plant Geneticist.—L. R. Doughty, B.Sc. (Agric.) N.D.A.

Superintendent of Plantations.—F. M. Rogers.

Secretary and Librarian.—R. E. Moreau, C.M.Z.S., M.B.O.U.

Botanist.—P. J. Greenway, F.L.S.

Assistant Superintendent of Plantations.—C. B. Gibbins.

Assistant Secretary and Librarian.—W. M. Nutter.

Engineer Mechanic.—T. V. Greenwood.

Scientific Assistant (Plant Path.).—R. F. W. Nichols.

Scientific Assistant (Soil Chem.).—W. E. Calton, B.A., Dipl. Agric.

LEAVE MOVEMENTS, 1939.

	Departed.	*Returned.*
Mr. W. M. Nutter	—	4.2.39
Mr. R. F. W. Nichols... ...	—	24.2.39
Mr. W. E. Calton	28.2.39	—
Dr. H. H. Storey	20.3.39	—
Mr. R. E. Moreau	20.3.39	—
Mr. T. V. Greenwood... ...	18.4.39	—
Dr. R. R. Le G. Worsley ...	25.4.39	—

SPECIAL TEMPORARY POSTINGS IN CONSEQUENCE OF WAR.

Mr. W. M. Nutter to Information Department from 7.9.39.

Mr. G. Milne to Coffee Research and Experimental Station, Lyamungu, from 1.11.39.

Messrs. Doughty, Nichols and Gibbins also served in other departments for short periods during September and October.

REPORT OF DIRECTOR.

Research.

Policy.

The East African Agricultural Research Station and the Imperial College of Tropical Agriculture, Trinidad, are the only representatives of the proposed chain of Imperial agricultural research stations the function of which was laid down in the recommendations of the Imperial Agricultural Research Conference, 1927. The policy of the East African Agricultural Research Station, based on the recommendations of that Conference,* is directed towards the solution of the major agricultural problems of East Africa, research work of a fundamental and long-range character being its primary function. This policy, which also provides for the undertaking of special investigations as circumstances demand and as means permit, is designed to supplement and reinforce the research work of the East African Agricultural Departments by undertaking investigations of a more prolonged nature than such departments can normally be expected to undertake. Advisory and teaching duties are not part of the Station's functions.

A research programme for the Station, based on the above policy, was drawn up by the Director and a special committee of the Colonial Advisory Council in 1927 and, with some modifications, was adopted by the Conference of East African Directors of Agriculture held at Amani in 1931. This programme was to be subject to review periodically, and was modified in 1937 after the East African tour of the Agricultural Adviser to the Secretary of State, as outlined in his report (C.A.C. 345, pp. 108–111). In December, 1939, I submitted proposals for further modifications as the result of the war. All these programmes have been of necessity highly selective because of the enormous disproportion between the small staff of the Station and the extent of the six territories it is designed to serve. At the founding of the Station it was recommended that there should be at least two first-rate scientific workers for each department of the Station but this minimum has never been realised.

A statement on the particular aims of the current programme, which includes the improvement of native food crops, will be found in the following summary of the year's work.

In view of the need for reducing the size of this report the sectional reports have been condensed and the summaries of these reports which it has been customary to include in this part of the Report have been omitted. It can be said that allowing for the limitations imposed by lack of subordinate staff, leave movements and the interruptions due to the war, steady progress has been

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* See 2nd Annual Report of this Station; 1929–30 (Colonial No. 51), p. 6.

made by the Station during 1939. Dr. Nutman was awarded the D.Sc. by London University during the year for his research work at Amani.

The Improvement of Native Food Crops.

During the year, in consultation with the six Directors of Agriculture, I drafted proposals for a general scheme for the improvement of native food crops in East Africa by selection, breeding and introduction. This scheme was acceptable in general although several modifications, which in no way interfered with its main purpose, were suggested. The scheme was accordingly modified and the following proposed statement of policy submitted to the Directors for approval in December. This it is believed will be found acceptable, although it is realised that the carrying out of a programme based on this policy must be governed by the exigencies of the war :—

(i) That the collection of local varieties on each experiment station should be extended and all relevant information concerning their desirable and undesirable characters should be compiled.

(ii) That new varieties should be imported with the main objects of remedying the undesirable characters of local varieties and introducing new crops not established in East Africa.

(iii) That the primary (mass) selection from local and imported varieties should be undertaken for yield, disease and pest resistance and native preference ;

(iv) That crossing work should be put in hand when it is evident that no further improvement is being obtained by continued selection from among local and imported types.

The improvement of the African's diet is intimately connected with the diversity of available foodstuffs and, while the crop aspect of this problem is covered by the policy outlined above, the assessing of the dietetic values of the various crops and the designing of balanced diets fall within the province of the nutrition workers, so that further developments in this connection must await their findings and recommendations.

The part that the East African Agricultural Research Station should play in the scheme is still under discussion. It is proposed that the Station should be responsible for :—

(i) The general correlation and the dissemination of results obtained in the several Dependencies ;

(ii) Investigations that may be outside the scope of the departments, *e.g.*, certain aspects of the *Striga* problem and the genetical study of the *Pennisetum spp* ;

(iii) The maintenance of a central collection of introduced food plants from which Agricultural Departments could obtain material for trial and selection ;

(iv) The botanical study of East African food crops ;

(v) The supply of information.

It is impossible to carry out the suggestion that the Amani staff should undertake breeding work with native food crops, unless the existing research programme is modified, or the staff increased, and a suitable sub-station established.

During the year I prepared and distributed a condensed summary of the work done in the six territories during 1938 for the improvement of native food crops. This was prepared from advance extracts of departmental reports kindly provided by the Directors and should serve to keep workers in touch with latest developments in neighbouring territories without the delay occasioned through waiting for the printed reports. At Amani *Striga* investigations were begun during the year and food crop varieties were collected, multiplied and distributed. The activities of the Geneticist, Plant Pathologist, Botanist and Superintendent in connection with this scheme are dealt with in their reports below.

Inter-territorial Coffee Research Committee.

At a meeting held at Nairobi in March, at which I presided, the committee were informed that although the Conference of East African Governors had approved the committee's proposals for an augmented coffee research programme in East Africa to be conducted from Amani, the Governments concerned were, unfortunately, not prepared to finance the scheme. The need for making increased provision for coffee research was again stressed by the committee who discussed the many outstanding problems needing investigation.

Administration.

The financial statement for 1939 appears on p. 23. Following the outbreak of war, the work of certain sections of the Station was temporarily interrupted as shown in the statement on staff movements on p. 3.

An increased amount of travelling was undertaken in 1939, all the contributing territories having been visited by one or more members of the staff. In March, April and May I visited Kenya, the Southern Highlands of Tanganyika, Northern Rhodesia and Nyasaland. The Soil Chemist and the Geneticist paid separate extended visits to Uganda visiting Kenya *en route*. The Geneticist also visited some of the more important *Striga*-infested areas of Tanganyika. Five members of the staff visited Zanzibar at different times during the year in connection with the " sudden death " disease of cloves.

Buildings constructed at Amani during the year included new quarters of the Plant Pathologist, eleven permanent quarters for African employees, a covered market and a large covered cattle-pen.

Amani Plantations.

Apart from ordinary maintenance operations, field work increased during the year, chiefly as the result of work with native

food crops, the renovation of neglected oil-palm plantations and the first plantings of the new fuel reserve programme.

During the year most of the native food crop varieties were transferred to Kizugu, ten miles distant, where conditions for such crops are better. The additional cost of this work is being borne from savings in the Amani labour vote.

In consequence of the chronic shortage of organic manure experienced in recent years the modified Indore process used was abandoned and a form of the Mauritius system adopted instead, a large covered cattle-pen being built for the purpose.

As the result of the war a difficult situation has arisen owing to the disappearance from the market of certain specific proprietary drugs of foreign manufacture used for the treatment of endemic trypanosomiasis, a constant source of trouble in the herds at Amani and Kwamkoro.

With a view to remedying the Vitamin A deficiency in the local native diet, which consists largely of white maize and cassava, it was decided to exploit the hitherto neglected oil-palm plantations on the Station and to issue red palm-oil to our labourers at cost price. The experiment has proved popular and the demand exceeded the supply.

The Re-development of Kwamkoro Estate.

The object of this scheme, adopted in 1935 and financed by the Colonial Development Fund, is to investigate the possibility of establishing profitable industries on the abandoned coffee plantations of the East Usambara mountains by planting trial areas of the following crops thought to be of promise : *Cinchona, Aleurites montana, Derris elliptica,* robusta coffee, and arabica coffee, grafted on robusta stocks. Of these crops derris, *Cinchona* and *Aleurites* show the most promise up to date and coffee the least. Although it is too early to prophesy the success or failure of the scheme it is already clear that the original estimates of crop yields, made in 1935, were over-optimistic. As against this it will be possible to do without a European manager and the new coffee drying-house allowed for in the original estimates. Funds should therefore be sufficient to bring the scheme to fruition if strict economy is exercised. In this connection an area of approximately 25 acres of robusta coffee on the Mlesa area was abandoned in 1939 as being uneconomic.

During 1939 the first normal crop of derris root was harvested, previous crops having been adversely affected by the taking of cuttings. This crop of approximately 1,500 lb. of dried root, equivalent to half a pound per plant, was shipped to the United States of America for sale as a trial consignment. A sample analysis made before shipping gave a rotenone content of 9·05 per cent. and ether extract 22·80 per cent.

Reports on the state of the various crops at Kwamkoro will be found in the Superintendent's report (page 22).

East African Central Quarantine Station, Amani.

As in the past, full use was made of the quarantine houses, particularly for the introduction of sugar-cane, cassava, yams, sweet potatoes and *Passiflora* varieties.

East African Agricultural Journal.

The Journal was edited from Amani throughout the year. During Mr. Moreau's absence in the United Kingdom the Assistant Editor's work was done by G. Milne, and later, T. W. Kirkpatrick. The volume of original contributions, which was well maintained until the outbreak of war, has naturally suffered somewhat since. At the end of the year circulation had fallen slightly but it is noteworthy that the number of subscribers outside the East African territories exceeded 120.

The Amani Library.

Far less use than might be expected is still made of the facilities offered by the Amani library for the supply of books and periodicals on loan to Government officers in the contributing territories. Steps are being taken to bring the possibilities of the library's usefulness once more to the notice of departmental officers, although it is recognised that under present conditions the time they have available for reading and study is less than ever before.

A. GLENDON HILL,
Director.

PLANT PATHOLOGY.

In the past the policy of this section has been to maintain a balance between the more fundamental and the more directly applicable lines of research. The year 1939 was one of transition, enforced, not merely by the war, but by the increasing momentum of the second class of research. The effect was accentuated by the absence on leave of one or other of the two members of the staff.

The outbreak of war thus found the fundamental side of the research necessarily in abeyance. Had peace continued there would have been little immediate opportunity for its continuance on any considerable scale. It is perhaps appropriate that in war our whole efforts should go into projects whose goal is not too distant.

The work that now takes chief place in our programme has the objective of assisting Agricultural Departments in the improvement of the two important native food crops, cassava and maize. So long as cassava continues to be the most reliable and most adaptable carbohydrate-producer available to native agriculture, it must, I assume, despite its well known dietetic deficiencies, maintain its

place in East African agriculture. On this score the relation of our research to agricultural policy in general is evident; in peace or war the maintenance of the native food supply must remain an important feature of any policy. Work on the raising of maize resistant to streak disease has barely begun; but if successful it also should contribute to native production of food in many areas.

Virus Diseases of Plants.

The Mechanism of Transmission by Insects.

With the publication in October, 1939, of the third of a series of papers (*Proc. Roy. Soc. B. 127*, 526) I completed the account of the main physiological studies of virus transmission by *Cicadulina mbila* carried out during the last ten years. The substance of this paper was given in my last annual report.* This series of papers has, I believe, contributed something not inconsiderable to knowledge; they have evoked wide interest and have given a lead in a small field to world research. If for the present they must be discontinued, it is at least satisfactory that the main facts discovered have now been placed on record.

A final report on my genetical studies on the ability of *Cicadulina* to transmit awaits preparation, although the data are assembled. With the promised assistance of Professor R. A. Fisher and Dr. K. Mather of the Galton Laboratory, I expected to publish this report in 1940. Further delay, however, now seems inevitable.

Early in 1939 the American "Botanical Review" published a paper, in which I reviewed and discussed all the available evidence bearing on the mechanism of insect transmission of viruses.

Virus Diseases of Cassava.

Early investigations, recorded in successive annual reports, centred around the viruses that cause cassava diseases. A knowledge of them is an essential preliminary to sound control measures, and appeared an appropriate contribution by Amani to agricultural progress.

Our studies have shown that mosaic disease is caused not by a single virus as previously supposed, but by a group of virus strains of varying virulence; and that there is a second distinct virus disease, termed by us "Brown Streak," not previously recognised. The vector of the mosaic viruses was found at Amani (independently of other workers at about the same time in West Africa and Belgian Congo) to be the White-Fly, *Bemisia* sp., and the peculiar conditions controlling transmission were elucidated. Work by Mr. Nichols during my absence on leave has almost certainly identified the vector of brown streak; but confirmatory experiments will be completed before a definite statement is made.

It must be admitted as a failure in the liaison between Amani and Agricultural Departments that reports frequently write of "mosaic

* Colonial No. 167 (p. 13).

disease " as if there were only one important virus disease of cassava. I have tried to emphasize the importance of brown streak by correspondence and personal visits to the stations where cassava investigations are in progress ; but the value of these visits has often been lost by changes of personnel. Differentiation of mosaic and brown streak is not easy ; and I hope in 1940 to improve the position by more visits and by publishing a more complete account of brown streak than that at present available (*East Afr. Agric. J.*, July, 1936).

During the early years, I assumed that the application of this knowledge, mainly in the direction of selecting resistant types of cassava, would remain in the hands of Departments. However it became evident that Amani could contribute directly by undertaking certain phases of breeding for resistance. This course was specifically recommended by Sir Frank Stockdale as a result of his visit in 1937.

It was evident that no progress could be made so long as field work remained confined to the Amani Estate. The opening in 1938 of the Kizugu sub-station, ten miles away, was an essential preliminary. The first trial there, planted late in 1938 to include 100 clones in a triple lattice design, showed that we had successfully established an extremely high infection rate ; and that among the varieties tested there is a wide range of resistance to both viruses. An important point to be decided is whether behaviour at Kizugu will prove a true index of behaviour elsewhere in East Africa.

A consequence of the development of Kizugu is that we can now defer distribution of imported varieties until they have shown promise in our trials. Some reports from Departments have shown impatience with our past policy of distributing untested material—the only policy then available to us. It is not unexpected that the great majority of the exotic varieties have proved markedly inferior to local selections.

Further trials are in progress at Kizugu. Meanwhile a new enlarged maintenance plot has been established at Amani to replace the old one in which *Armillaria* root disease had become rampant.

Although it is still too early to assess the value of our hybrid material, it provides encouragement for further breeding. The first generation plants of the Cassava x *M. glaziovii* cross are fertile, and an open-pollinated F2 generation has been raised. Controlled pollination has been deferred until trials in progress have permitted selection of the most promising parents. No Cassava x *M. dichotoma* has yet contracted any virus disease ; but none is of any economic promise and all are apparently sterile. With a view to obtaining fertility by induced polyploidy, Mr. Nichols experimented with colchicine treatment and obtained some plants consisting at least in part of polyploid tissue. This line of work is continuing, with the co-operation of the Geneticist in cytological studies.

Streak disease of maize.

Further experiments during 1939 confirmed the high resistance to streak disease of certain lines of the Peruvian Yellow Flint variety, selected at the Cotton Breeding Station, Barberton, South Africa. The project of breeding a commercial type from these extremely delicate inbred lines has been included in the 1940 programme of this section.

Virus Disease of Passion Fruit.

This investigation is now in the hands of the Kenya Department Plant Pathologist, and our part has been confined to the introduction of seed of *Passiflora* spp. Through the co-operation of many correspondents, and particularly of Sir Geoffrey Evans at Kew, we have assembled a considerable collection.

"Sudden Death" Disease of Clove Trees.

Investigations of this disease have been conducted by a special research officer, Dr. A. H. Campbell. I visited Zanzibar in March, 1939, for a discussion with him of this very obscure problem.

General.

During September, 1939, I visited the United States of America. I attended the Third International Congress of Microbiology, reading a paper on my studies of insect transmission of viruses, and afterwards visited a number of research laboratories. I am greatly indebted to the Carnegie Trustees for making possible this valuable tour. While in England I visited Rothamsted, Cambridge, and the Galton Laboratory of the University of London.

I again place on record the important part played by Mr. R. F. W. Nichols in the work of the section. For ten months of 1939 he carried the sole responsibility with conspicuous success.

H. H. STOREY,
Plant Pathologist.

ENTOMOLOGY.

The work of this one-man section consists, as laid down by the Colonial Advisory Council, of an investigation into the ecology of coffee plantations by means of detailed studies of particular insects of importance. This work should, if successful, result in a wider understanding of insect pests in general than can be expected from *ad hoc* investigations. Unless the services of the section should be required for other work considered of more immediate value in war-time, the programme will be continued.

Throughout the year I have continued work on the leaf-miners (*Leucoptera* spp.) attacking coffee. In my report for last year* the two species occurring in East Africa were referred to as species A, probably correctly known as *L. coffeella* Guér and species B, previously, but almost certainly incorrectly, known as *L. daricella* Meyr. This latter species has now been described as new by Mr. R. Washbourn of the British Museum (*Bull. ent. Res.* 30, pp. 455–462, Jan., 1940) under the name *caffeina*. The two species are therefore now known as *L. coffeella* Guér, and *L. caffeina* Washbn.

It must be admitted that so far the results of my work are disappointing, for the solution of the fundamental problem, namely, the causes of occasional violent fluctuations in population, still eludes me.

I have kept in close touch with Mr. F. B. Notley, of the Coffee Research Station, Lyamungu, who is also working on coffee leaf-miners. Mr. Notley visited Amani in August and I spent some days at Lyamungu in March. The fact that both *L. coffeella* and *L. caffeina* appear to behave differently on Kilimanjaro and in the East Usambaras, and that we are in friendly disagreement about several points, should dispel any fears of " overlapping ".

Dr. W. H. Thorpe, of the University Museum of Zoology, Cambridge, spent several months during the year in East Africa, working mainly at Amani, on parasites of Coccids. It is, I hope, unnecessary to emphasize the benefits to be derived by us from such visits.

T. W. KIRKPATRICK,

Entomologist.

SOIL SCIENCE.

Progress during 1939 was limited by absences, partly due to leave and partly attributable to the war. Mr. Calton, Scientific Assistant, went on leave on 28th February and was away ten months. I was posted away from the Station for the last two months of the year, as a relief Agricultural Officer. The laboratory was closed in March and most of April when I was in Uganda, and again in November and December ; from January to the end of May, part of it was in workmen's hands for alteration.

Visit to Uganda for Soil Reconnaissance.

The purpose of soil reconnaissance is to lay the foundation of a general knowledge of soils, and of the relations between soils and land utilisation, in areas where existing soil data are few, or relate only to special problems and scattered localities. Previous work of this kind done departmentally in Uganda was the basis of the Uganda section of the *Provisional Soil Map of East Africa*, drafted in 1935. With a view to improving this map, collecting material

* Colonial No. 167 (p. 20).

for a revision of the soil classification, and compiling a fuller account of soil conditions, I had been invited to visit Uganda in 1937. The journey was not then found practicable, but was carried out in February, March and April, 1939, when about 4,000 miles were covered within the Protectorate and all the districts were visited except Karamoja. I was accompanied throughout by one or other of the Agricultural Chemists (Dr. W. S. Martin and Dr. G. Griffith), usually also in each district by the Agricultural Officer. I received assistance also in various ways from the Forest, Veterinary, Geological and Survey Departments.

The reviewing of notes and samples from this Uganda journey was interrupted by work on Zanzibar soils, but was well forward when work was stopped in October; the analytical work, report, and revision of the map remain to be taken up again when normal work can be resumed. It is already clear that in the map as drawn in 1935 the representation of Uganda soils was over-simplified. The group of plateau soils occurring extensively in Tanganyika needs to be shown here too, and may call for some sub-division. Mapping can now be carried as far north as the Sudan border. Reports of reconnaissances recently carried out by Dr. H. Greene in the southern Sudan show that there is similarity of soils and of general conditions across the boundary, and co-relation between the Uganda and the Sudan mapping should not be difficult.

Zanzibar.

A soil reconnaissance of Zanzibar and Pemba was made in 1935 and a "Sketch of Soil Conditions" in the two islands was written and circulated at that time. In 1938 a plant pathologist (Dr. A. H. Campbell) was appointed to Zanzibar to study the "Sudden Death" disease of the clove tree, and by June, 1939, he had decided that more information was needed on the soil properties and state of fertility of some of the clove lands. After a period of further analytical study of the material gathered in 1935, I visited Zanzibar in August. During the visit a programme of further sampling of certain clove areas was arranged, the intention being to amplify the reconnaissance information, which was subject to too great a "sampling error" to be made the basis of argument for Dr. Campbell's purposes. The numerous analyses required were to have been carried out at Amani by the Zanzibar and Amani chemists in collaboration. These arrangements were however suspended on the outbreak of war.

Soil reconnaissance so far carried out in Zanzibar and Pemba has indicated a rather intricate distribution of soil types, differing a good deal from each other, especially in nutrient status and mineral reserves. It has been possible to describe the main types but not to plot their occurrence accurately on a map. Without further investigation on the spot, therefore, it cannot be said which of several quite different soil conditions may be involved, when a problem in crop behaviour arises in some particular area. The value

of the preliminary recognition of soil types thus remains in suspense, as regards practical usefulness, until the detail is developed—in other words until soil survey in the proper sense succeeds soil reconnaissance.* There is a strong case for beginning this second stage, not only on the clove lands but on the agricultural lands as a whole. During my visit I took the opportunity to discuss, with the Director of Agriculture and the Chief Secretary, what might be the objectives of a soil survey of the Protectorate, and its probable cost. Later I submitted, by request, a memorandum on the practicability of soil amelioration as it would have to be carried out by the small proprietors of land. The principle was urged that a landed peasantry should always be regarded as able to afford a proportion of the proceeds from the sale of its crops, for the benefit of its land.

Miscellaneous.

A little progress was made with analytical work in arrear from the reconnaissances of previous years, but the arrears remain considerable.

The report on my study journey to the West Indies and the United States in 1938 was completed, and is being printed for wider circulation.

From May to December I did duty as Assistant Editor of the East African Agricultural Journal, and contributed reviews and short articles.

G. MILNE,
Soil Chemist.

BIOCHEMISTRY.

Vegetable Insecticides.

This report only covers the period January to mid-April, when I went on leave. During this time I completed histological work, the results of which have now been published (*Ann. Appl. Biol.* 26, 649–683, Nov. 1939).

The aims of my work are to determine the locations, methods of formation and functions in the plants of the toxic substances, and thus to obtain the fundamental knowledge necessary for an understanding of the toxic principle of these plants. The paper just published covers the locations of these substances and preliminary results on their functions; work is now proceeding in several directions to elucidate the latter.

Fourteen rotenoid-containing species of Papilionaceae were examined. Rotenoid cells in roots and stems are normal ones but in other tissues are usually morphologically distinct and frequently relatively large (up to 150 times the volume of surrounding cells);

* The same point was emphasized in another connexion in my last annual report (1938, pp. 24–25).

lysigenous cavities, up to 1,650 times normal cell size, contain rotenoids in the seeds of species of *Derris* and *Millettia* ; in many species rotenoids can first be detected in young plants in the root cortex opposite the protoxylem and primary medullary rays.

On germination there is an increase in rotenoid content followed by a decrease, in some cases to nil. This would indicate that the rotenoids are utilized by the seedling ; in all other tissues they appear to be waste products.

In some species there is an increased amount of rotenoids at nodes and other points of secondary growth.

The two derris plot experiments are in good order : a derris nutrition——sand culture experiment is in progress and manurial and spacing experiments are being started at Kwamkoro.

Whilst in England I had valuable talks on my work with Professor Gregory, Dr. Tattersfield, the Director and other members of the Imperial Institute, Professor Engledow and others.

R. R. WORSLEY,
Biochemist.

PLANT PHYSIOLOGY.

The aim of this section is, by studying the physiological reactions of crop plants to natural, uncontrolled, conditions, to provide the essential data and concepts by means of which the practical worker can evolve an improved cultural technique.

I have completed a study of the transpiration of *Coffea arabica* in the field. I find that the transpiration rate fluctuates very rapidly, mainly with the incident radiation. The total daily transpiration is independent of temperature but controlled largely by the saturation deficit of the air. Shade affects transpiration mainly through its effect on this saturation deficit, for the reduction in radiation is largely compensated for by increased stomatal aperture. The slightest wilting reduces transpiration very greatly.

The practical inferences from this work are that shade, unless heavy enough to modify the saturation deficit of the air beneath it, will not have much effect in reducing water-loss from coffee, at any rate under clear skies. In fact the water-loss might be greater in a shaded than in an unshaded plantation. In dry conditions considerable internal control of water-loss is exercised by the coffee-bush, though whether at the expense of other, constructive, functions, is not known.

Mr. Glover has completed the apparatus, referred to in the last annual report,* for the continuous measurement of the transpiration of a single leaf and has obtained data on the behaviour of *C. arabica* in the field.

Three papers on the above work have been accepted for publication.

* Colonial No. 167 (p. 31).

Mr. Glover has begun a study of the water-losses of *Agave* spp., using the methods found successful with coffee, and he has also collected data on the "poling" of sisal.

In connection with the "sudden death" disease of the clove tree I have visited Zanzibar twice this year, accompanied on the second visit by Dr. Herklots and Mr. Glover. In consultation with Dr. Campbell a provisional hypothesis has been formulated and some physiological work preliminary to testing it has been done in Zanzibar by Mr. Glover. One useful result is that now for the first time a tree in the very early stages of the disease can be recognised.

The apparatus for the determination of carbon dioxide by physical means (referred to in my last annual report) has arrived and is now being calibrated.

F. J. NUTMAN,
Plant Physiologist.

PLANT GENETICS.

General.

During March and the first weeks of April I visited Uganda and parts of the Lake and Western Provinces of Tanganyika. The objects of this journey were: (*a*) To study wild population of *Coffea*; (*b*) to obtain material of *C. arabica* x *C. excelsa* hybrids for cytological study; (*c*) to discuss all aspects of the problems presented by the attack of *Striga* spp. on grain crops and, in particular, the possibilities of breeding resistant forms of the host plants.

In August I spent a few days in the West Usambaras visiting estates interested in cinchona planting.

Agaves.

A field trial comparing the development and yield of blue sisal and sisal was cut for the fourth time. There has been a considerable slowing down in the rate of leaf production in blue sisal and at this cut produce a much lower yield of leaf than sisal. The total yields of leaf from the two species up to date do not however show significant differences.

Seedling and hybrid material at the Sisal Experimental Station, Ngomeni, has made steady progress. Some of these hybrids are nearing the poling stages and will thus soon provide material for further breeding work, and also provide vegetatively-propagated material in sufficient quantity to enable accurate comparisons of the most promising types.

Several species of Agave have flowered during the year and a few more crosses have been made, including an attempted intergeneric cross, *Agave* x *Furcraea*, which however failed. Other species are beginning to pole, including an unnamed tetraploid species, obtained from La Mortola, which possesses some desirable characters. A crossing programme utilising these species has been drawn up.

Coffee.

The outbreak of war interfered with the crop-recording programme, particularly for robusta, which carried a heavy early crop this year. Vegetative propagation of selected trees of this type is proceeding slowly.

Seven selected plants in three families of inbred *C. arabica* have been selfed, apparently with satisfactory results. Crosses between *C. eugenioides*, *C. canephora* and *C. excelsa* have also been made in all combinations.

Exotic *Coffea* spp. flowering during the year include one from Madagascar (identity uncertain) and *C. travancorensis*. The former set fruits but *C. travancorensis* appears to be self-sterile. A large number of seedlings of wild types of *C. canephora* and *C. eugenioides* have been raised from seed collected in Uganda.

Cytology.

Meiosis in the hybrid *C. arabica* x *C. excelsa* has been studied in the material obtained from Uganda, and is similar to that observed in the hybrid *C. arabica* x *C. canephora*.

Chromosome counts in the root tip of the hybrid *C. arabica* ($2n = 44$) x *C. eugenioides* ($2n = 22$) show that three plants have 33 chromosomes and two only 32. A re-examination of slides of pollen mothercell divisions in *C. arabica* indicates that failure of pairing between two or four chromosomes is more frequent than was at first noted and a further study of meiosis in different varieties and aberrant forms of this species is required.

Colchicine treatment.

Attempts have been made to induce chromosome doubling in both *Coffea* and *Agave* by treating germinating seedlings and young plants with colchicine. Treatment of germinating seedlings seems to be the most promising method if the effect of the drug on root development can be overcome.

Striga.

There is little published information on the life history and host range of *Striga hermonthica*, the most destructive species in the sorghum-growing areas around Lake Victoria. In India, Burma and South Africa the search for varieties of crop plants resistant to attack by *S. asiatica* is meeting with some success and a few resistant varieties have been imported from these countries in the hope that they may prove resistant to *S. hermonthica*.

Some preliminary experiments have been carried out at Amani with a view to devising a technique for testing resistance of varieties to the parasite under controlled conditions. Cultures of various host plants in buckets containing an equal quantity, by weight, of

Striga seed have given interesting results. The salient features of these experiments to date are :—

(1) Bulrush millet (*Pennisetum typhoideum*) appears to be resistant to attack by both *Striga* spp. The seeds of the parasite do not appear to germinate readily in the presence of this host and the plants that do develop are dwarfed and do little damage to the host.

(2) In the first experiment only five of the parasitic plants (all *S. hermonthica*) appeared in eight buckets of the resistant sorghum from Burma. During the second experiment a large number of parasites of both species developed.

(3) Both species of *Striga* have germinated readily on maize, ordinary sorghum and Rhodesian sorghum (the so-called biennial sorghum).

Aleurites montana.

Yield records for individual plants of this species were begun in 1938. In 1939, the yields from 136 trees were recorded. These may be regarded as a sample of the progeny of two trees, raised from the seed originally imported in 1930, that have made the most satisfactory progress. These two trees were left in the nursery bed after the remainder had been transplanted into the field. Very few of the transplanted plants survive and the survivors have not in general developed satisfactorily.

Cinchona.

There is little to report under this heading. Young plantations at Kwamkoro have been inspected from time to time and it is obvious that a good deal of the variability in development is attributable to differences in environment. There is a wide range of variability in leaf type among the plants raised from Indian seed.

Cassava.

A cytological study has been made on *Manihot* species and interspecific hybrids raised by the Pathologist.

The following species have $2n = 36$ chromosomes : *Manihot dichotoma* Ule ; *M. Glaziovii* Muell. Arg. ; *Manihot* sp. received as *M. cathartica* ; *M. utilissima* Pohl. (cassava and a tree form) ; *M. dulcis* (J. F. Gmel.) Pax.

Hybrids between cassava and the tree form, probably varieties of the same species, show complete pairing of chromosomes at meiosis in pollen mother cells. The hybrid *Manihot utilissima* x *M. Glaziovii* occasionally has two univalents. In the hybrid *M. utilissima* x *M. dichotoma* some plants show complete pairing and others a high proportion of univalents. The cause of the difference in behaviour is not yet clear.

A large number of buds on rooted cuttings of the interspecific hybrids has been treated with colchicine. Chromosome counts in the root tip of a cutting from a shoot arising from a treated bud

indicate that the plant is a sectorial chimaera of diploid and tetraploid tissue. Meiosis has been studied in the pollen mother cells of other treated material but no evidence of chromosome doubling has been seen.

Other Activities.

In addition to the work described above there are certain other calls on my time. Amani has become a second-order Station of the British East African Meteorological Service and the training of two African Observers has been undertaken by the Botanist and myself. They have developed into fairly competent observers but still require close supervision.

Supervision of the work of the Native Veterinary Assistant and the management of the dairy herd is also one of my duties.

I also assist the Director in his work on native food crops as circumstances permit, and have also undertaken some breeding work with *Pennisetum typhoideum* in an attempt to fix some desirable but elusive head characters.

For three weeks in September I was seconded to the Custodian of Enemy Property's office in Dar es Salaam.

L. R. DOUGHTY,
Geneticist.

SYSTEMATIC BOTANY.

The relationship of my work to agricultural problems of the East African territories requires no stressing. I deal not only with Agricultural Departments but with Veterinary, Forestry, Medical Education, Administration, Police and Geological Departments, as well as institutions and private individuals. In fact, the section, in addition to its activities as a herbarium, acts as an information bureau not only on the flora of East Africa but on economic plants in general.

My work for the year has been confined to making routine determinations and supplying information. Although this resulted in a decrease in the arrears that had accumulated during my absence on leave and visit to Northern Rhodesia, the receipt of more specimens this year has brought the work to about its previous position. I cannot hope to do more in the field or further to reduce arrears of identifications, since through the outbreak of war and the consequent long delay and uncertainty of sending specimens to European herbaria, I have been asked to undertake determinations for the Tsetse Research Department's vegetation surveys and for the Coryndon Memorial Museum, Nairobi. Moreover, the nutrition surveys inaugurated by Dr. B. S. Platt have brought further work in the way of determinations, as specimens of all plants used in the dietary of the African are being sent to Amani for identification.

Towards the end of the year I completed the revision of my " Swahili Dictionary of Plant Names ". The usefulness of the new edition, which is now in the press, has been increased by adding over eighteen hundred Swahili names and giving English-Botanical-Swahili names as well as the Swahili-Botanical-English. The greater part of this work has been done outside official hours.

I am continuing the collection of information on plants of importance in African economy. The information so far gathered is already proving of value in nutrition surveys, as I was able to supply the Provincial Medical Officer, Tanga Province, Tanganyika, with a comprehensive list of native vegetables used locally, together with their native names, mode of employment, distribution, and published data on composition and vitamin content. Eventually I hope to publish an account of the indigenous plants used as vegetables by the East African peoples in general.

Work on the " Check List of Trees and Shrubs of Tanganyika " for the Imperial Forestry Institute has been recommenced but is proceeding very slowly owing to many interruptions with more urgent matters. I have also yet to complete my account of the vegetation of Mafia Island, the publication of which will be undertaken by the Linnean Society.

P. J. GREENWAY,
Systematic Botanist.

ORNITHOLOGY.

My scientific work has been primarily a contribution to the biological survey of East Africa, a survey necessary to provide knowledge of the conditions in which agricultural development must take place. It is more important to ascertain the distribution in terms of habitat than in terms of geography, and to investigate the factors that determine the choice of habitat and control specific populations. Hence my work has been extending on the one hand into a study of general principles, such as the climatic controls and the determinants of the reproductive rhythm, on the other hand into the life-histories of particular species. My investigations have of necessity lacked the unity I should have wished because the projects undertaken have been determined by my absorption in administrative duties during official hours and by the financial assistance I have had from outside bodies.

" A contribution to the ornithology of the East African islands," which deals especially with the birds of Mafia, has been accepted for publication. In collaboration with Mr. R. H. W. Pakenham, of the Zanzibar Administration, the study of all the land-vertebrates of Pemba, Zanzibar and Mafia has been pursued throughout the year. With the generous assistance given by the staff of the British Museum (Nat. Hist.) check-lists have been prepared *de novo* for reptiles, amphibia and mammals. A paper has been completed

that embodies this information and discusses the faunae in relation to the respective islands' histories, physical characters and chances of colonisation from the mainland.

Available data on the rhythm of bird behaviour at the nest has been analysed (*Bull. Brit. Orn. Club*, 59, 145–149, 1939). The indication that certain rhythms may be specific is of fundamental interest to animal psychology and physiology. I hope to obtain further funds for this work, as before, from an outside source. Thanks are due to Mr. W. G. Cochrane of Rothamsted for statistical assistance.

At the British Museum Mrs. Moreau and I searched the literature of South African ornithology for records of clutch-size. I hope to investigate the relationship of clutch-size to latitude and habitat, a subject fundamental to problems of bird population.

Papers have been accepted on the incubation and fledging periods of African birds and on the biology of hornbills. During my leave papers were read to the British Ornithological Society, the Zoological Society of London and the Oxford Ornithological Society.

A request has been received from the United States Department of Agriculture for permission to re-publish my paper on "Climatic classification from the standpoint of East African biology" (*J. Ecol.*, 26, 467–496, 1938) in mimeographed form for the use of the staff of the Department.

R. E. MOREAU.

PLANTATION WORK.

Plantation and nursery work increased considerably during the year, owing to the introduction, planting and distribution of native food crops; renewed interest in the oil-palm plantations; the first plantings in the programme for establishing fuel reserves; extension of the manila hemp areas; preparation of land for the Plant Pathologist's cassava disease investigations; and the continuation of the Kwamkoro development scheme.

Amani Plantations and Nurseries.

Tuba Root. Derris elliptica.—Grafting the following species and varieties was carried out on unrooted cuttings, with nearly 100 per cent. success in all combinations:—*D. elliptica*, amani strain, on *D. elliptica*, low grade strain; *D. elliptica* on *D. polystachya*; *D. malaccensis* on *D. elliptica*; and all reciprocals.

Cinchona.—The plot of *C. Ledgeriana* raised from Indian seed has been extended, and the plantation as a whole shows good promise.

The ratooned area of *C. Ledgeriana* and hybrid originally planted in 1923 was harvested. The crop was poor, one ton of Ledger bark and one ton of hybrid (dry weight).

Coffee.—Raising of seedlings in connection with the Geneticist's breeding work continued.

Blue Sisal. Agave amaniensis.—Sixty-three thousands bulbils were despatched to Kenya Colony.

Oil Palms. Elaeis guineensis.—One hundred and ninety pounds of palm oil expressed in a hand press was issued to the native employees at cost price.

Manila Hemp. Musa textilis.—The plantation has been extended by four acres, using the variety introduced from Java in 1904. A few beds of seedlings have also been raised.

Cloves. Eugenia caryophyllata.—Experiments were carried out with inarching and approach grafting of cloves on guava (*Psidium guava*) and rose-apple (*Eugenia jambos*). Thirty-five out of forty-two grafts on guava were successful, compared with only two out of thirty-eight on rose-apple.

Eucalyptus spp.—Approximately 7½ acres of *Eucalyptus* species and two acres of *Calophyllum Inophyllum* were planted, the first in the new reafforestation programme for assuring future fuel supplies.

Tephrosia spp.—Of the 26 varieties of *Tephrosia Vogellii* imported during 1938, only 12 produced viable seed. From these, further plantings have been made for biochemical investigations.

Native Food Crops.—Multiplication of various native food crops for distribution has continued. Varieties of the following were distributed : sweet potatoes, yams, pawpaw, pigeon peas, cucumber, beans, cassava, maize and soya beans. Imported seeds distributed directly include rice and millet.

Quarantine.—Importations through quarantine include cassavas, yams, sweet potatoes, sugar-canes, *Passiflora* spp.

Kwamkoro Estate.

From March the Goanese overseer was replaced by an African.

Robusta Coffee.—Approximately 25 acres which showed no promise have been abandoned. Two tons of clean robusta coffee has been harvested. The 10-acre plot under intensive cultivation continues to make good progress.

Arabica Coffee.—All but 1½ acres of the grafted arabica has been abandoned ; the remaining area shows fair promise but, at present, little difference between the grafted plants and those growing on their own root-system.

Cinchona.—The *Cinchona Ledgeriana* raised from selected Indian seed and also the *Cinchona* hybrids interplanted in the old *Coffea arabica* plantations continue to make good progress. Some areas of the earliest plantings of *C. Ledgeriana* are far in advance of the hybrids and the *C. succirubra* planted at the same time.

Tung Oil, Aleurites montana.—The trees made good progress, a number are now fruiting.

Tuba Root, Derris elliptica.—26,000 plants were planted during the year. Cuttings were rooted on the plantation site in nursery beds of river sand; 98 per cent. rooted and few losses occurred in transplanting from the nursery to the plantation. Over 250,000 cuttings were distributed. 2,811 plants dug gave 1,485 lb. of dried root. In view of the fact that cuttings had previously been taken from many of the plants the average of ·52 lb. per plant was considered satisfactory. The dried root sold in America for 9d. per pound.

Animals.—Sickness among the animals, mainly trypanosomiasis (*T. congolense*), was again prevalent. Mortality among the young calves, however, was much lower than in previous years. The Native Veterinary Assistant continues to do good work, and it is mainly due to his routine examinations of blood smears from all cattle that the death rate has been reduced.

F. M. ROGERS,
Supt. of Plantations.

APPENDIX A.

Financial Statement for the year ended 31st December, 1939.*

Revenue.

	£
H.M. (Imperial) Treasury	6,000
Contribution Tanganyika Territory	7,592
Contribution Uganda	2,278
Contribution Kenya	2,152
Contribution Zanzibar	1,200
Contribution Northern Rhodesia	300
Contribution Nyasaland	300
	19,822
Local sales	376
	£20,198

Maintenance Expenditure.

	£
Personal Emoluments	11,285
Passages	815
Pensions Contributions	2,261†
Laboratories	789
Publications	70
Office, Telephones and Contingencies	209
Materials	457
Freight and Transport	504
Travelling	1,055
Labour	1,527
	£18,972

* At the time this statement was compiled the final accounts for the year had not been received from the Accountant-General, Dar es Salaam. No important alteration is, however, expected.

† Includes arrear payments.

CAPITAL EXPENDITURE.

	£
Reconditioning electric generator	168
Re-building quarters	500
Laboratory equipment	205
	£873

Summary.

	£	£
Revenue	20,198	
Reserve on 31st December, 1938	4,044	
		24,242
Maintenance Expenditure, 1939	18,972	
Capital Expenditure, 1939	873	
		19,845
Gross reserve on 31st December, 1939		4,397
Capital expenditure authorised from reserve but not made in 1939	600	
Amount included in 1939 estimates for special transfer to meet future commitments on incremental appointments (the revenue being on a five years flat-rate basis)	172	
		772
		£3,625

APPENDIX B.

Meteorological Records.

As shown in the annexed table, the rainfall at Amani in 1939 was below the average in both total and effectiveness. The "long rains" were late; the "short rains" failed; and 41·5 per cent. of the year's total fell in the month of May. At Kwamkoro Estate less than 4 miles south of Amani, the total precipitation was above the average, but with over 45 per cent. of it coming in May the effective rainfall was really much below the average. Both recording stations are at an altitude of about 2,900 ft.

When the range of conditions within the Research Station boundaries is being considered, it may be noted that pre-1914 records in the lowest area, the Sigi Plantations, altitude about 1,400 ft. above sea-level, show the minimum temperatures there to run about 2°C. higher than those at Amani and the maxima about 5°C. higher.

	Rainfall at Amani.			*Temperature at Amani.*				*Rainfall at Kwamkoro.*		
		1939.		*Mean monthly maxima (°C.).*		*Mean monthly minima (°C.).*			*1939.*	
	25-year average ins.	*Ins.*	*No. of rainy days.*	*10-year average.*	*1939.*	*10-year average.*	*1939.*	*10-year average ins.*	*Ins.*	*No. of rainy days.*
January ...	3·22	3·29	9	26·8	26·1	17·8	17·4	2·26	3·82	6
February ...	3·28	·35	4	27·3	28·1	17·9	16·8	3·01	0·00	0
March ...	6·99	4·82	12	26·3	28·1	18·0	17·9	8·76	5·44	11
April ...	14·47	6·06	21	24·7	25·0	17·9	17·5	15·30	9·98	21
May	12·93	27·90	29	22·6	22·3	17·4	16·7	17·93	39·51	28
June	4·71	6·55	20	21·7	21·5	15·7	14·9	6·67	8·45	17
July	4·04	·83	11	21·3	21·5	14·9	13·3	3·97	1·04	7
August ...	3·86	2·42	20	21·3	20·9	14·3	13·4	4·82	3·37	17
September ...	4·09	6·63	18	22·1	22·1	14·6	13·6	4·95	8·37	16
October ...	6·42	2·82	11	23·4	23·1	15·4	15·2	7·37	1·51	5
November ...	6·51	3·69	15	25·2	25·5	16·6	16·3	5·26	3·50	14
December ...	6·89	2·04	18	25·8	27·1	17·6	17·4	6·17	1·70	13
	77·41	67·40	188	—	—	—	—	86·47	86·69	155

APPENDIX C.

List of publications distributed during 1939 by the East African Agricultural Research Station.

Memoirs.

63. A contribution to the biology of the Musophagiformes, the so-called Plantain-eaters. R. E. Moreau, *Ibis*, Ser. 14, Vol. 2, pp. 639–671, 1938.
64. Climatic classification from the standpoint of East African biology. R. E. Moreau, *J. Ecol.*, Vol. 26, pp. 467–496, 1938.
65. The comparative breeding biology of two *Euplectes* spp. in Usambara. R. E. Moreau and W. M. Moreau, *J. Anim. Ecol.*, Vol. 7, pp. 314–327, 1938.
66. Studies of the mosaic diseases of cassava. H. H. Storey and R. F. W. Nichols, *Ann. Appl. Biol.*, Vol. 25, pp. 790–806, 1938.
67. The root-system of *Agave sisalana* in certain East African soils. J. Glover, *Emp. J. Exper. Agr.*, Vol. 7, pp. 11–20, 1939.
68. Transmission of plant virus by insects. H. H. Storey, *Bot. Rev.*, Vol. 5, pp. 240–272, 1939.
69. Numerical data on African birds' behaviour at the nest. I. *Hirundo s. smithii*, the Wire-tailed Swallow. R. E. Moreau. *Proc. Zool. Soc. London*, Vol. 109A, pp. 109–125, 1939.
70. The histology and physiology of rotenoids in some Papilionaceae I. R. R. Le G. Worsley. *Ann. Appl. Biol.*, Vol. 26, pp. 649–683, 1939.
71. Investigations of the mechanism of the transmission of plant viruses by insect vectors. III. The insect's saliva. H. H. Storey, *Proc. Roy. Soc.*, Vol. 127, pp. 526–543, 1939.

Reprints and other Miscellaneous Publications.

7. Observations on some East African birds. R. E. Moreau and W. M. Moreau. *Ibis*, Ser. 14, Vol. 2, pp. 296–323, 1939.
8. The root-system of sisal in some East African soils. J. Glover. *East Afr. Agr. J.*, Vol. 5, pp. 18–22, 1939.
9. Experimental lemon-grass plots in Amani. R. R. Worsley, *Bull. Imp. Inst.*, Vol. 37, pp. 180–182, 1939.

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S.O. Code No. 88–303–80–39

The Director

Imperial Mycological Institute

Ferry Lane.

Kew.

Surrey.

(LABLARGE)

S. SECRETARY OF STATE FOR FOREIGN AFFAIRS
CONSULATE

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ON HIS MAJESTY'S SERVICE.